REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	4/25/96	Final, dates cover:5-1-92 to 12-31-95

4. TITLE AND SUBTITLE
Nature and role of marine exudates in particle aggregation in the sea (SIGMA ARI)

5. FUNDING NUMBERS
N00014-92-J-4073

6. AUTHOR(S)
Kenneth Mopper

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
Chemistry Department
Washington State University
Pullman, WA 99164-4630

8. PERFORMING ORGANIZATION REPORT NUMBER
11F-2452-0439

9. SPONSORING / MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
Office of Naval Research
Arlington, VA

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
N/A

a. DISTRIBUTION / AVAILABILITY STATEMENT
Unrestricted

12. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The overall goal of the project was to determine the importance of dissolved and colloidal exudates in flocculation of algae in the sea. Thus, during the course of algal blooms, we 1) studied bubble-generated, non-living background particles formed from *surface active* algal exudates, since these particles appear to play a key role in floc formation; 2) determined the molecular size distribution and composition of exocellular saccharides; and 3) related changes in exopolysaccharide composition and concentration (dissolved, colloidal, and surface active substances) to particle concentration and size distribution, to the formation of transparent exopolymer particles (TEP), and to variations in viscosity of the medium, alpha (the sticking coefficient), and microbial activity (i.e., exo-enzymatic hydrolysis, remineralization and synthesis of microbial exudates). This study has provided the first detailed molecular information on particle aggregation in the sea. This information is essential for understanding the molecular mechanisms that cause particles to adhere, and for modeling particle aggregation dynamics in the upper ocean. In addition, this study has provided important new information on the composition of marine dissolved and colloidal organic matter, and on the formation of non-living biogenic background particles.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Marine particles, aggregation, coagulation, flocculation, polysaccharides, carbohydrates, sea water	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

FINAL TECHNICAL REPORT N00014-92-J-4073

Submitted April 25. 1996 (revised April 11, 1997)

P.I.: KENNETH MOPPER

NATURE AND ROLE OF MARINE EXUDATES IN PARTICLE AGGREGATION IN THE SEA (SIGMA ARI)

Department of Chemistry
Pullman, Washington 99164-4630
PHONE: (509) 335-2116, Internet: MOPPER@wsu.edu

LIST OF PUBLICATIONS, PRESENTATIONS, THESES AND PATENTS

Refereed Journals and Chapters in Books:

Mopper, K. and K. G. Furton, 1991. Extraction and analysis of polysaccharides, chiral amino acids, and SFE-extractable lipids from marine POM. In: Marine Particles: Analysis and Characterization. Geophysical Monograph 63. D. C. Hurd and D. W. Spencer, editors, AGU Press, Washington, D.C., pp. 151-161.

Mopper, K., C. A. Schultz, L. Chevolot, C. Germain, R. Revuelta and R. Dawson, 1992. Determination of sugars in unconcentrated seawater and other natural waters by liquid chromatography and amperometric detection. Environ. Sci. Technol., 26: 133-138.

Mopper, K., J. Zhou, K. S. Ramana, U. Passow, H. G. Dam and D. T. Drapeau, 1995. Role of surface active carbohydrates in the flocculation of a diatom bloom in a mesocosm. Deep-Sea Res. II, 42: 47-73.

Zhou, J., K. Mopper and U. Passow, 1997. The role of surface-active carbohydrates in the formation of transparent exopolymer particles (TEP) by bubble adsorption. Limnol. Oceanogr., In press.

Manuscripts in Progress (To be submitted in 1996 and 1997):

Zhou, J. and K. Mopper, Role of surface-active carbohydrates in particle aggregation and flocculation of a coastal diatom bloom (East Sound, WA). To be submitted to Limnol. and Oceanogr.

Dam H. G., D. T. Drapeau, K. Mopper, J. Zhou, U. Passow and A. Waite, Effects of silica limitation on stickiness, carbohydrate and transparent exopoloymer particle concentration in a marine diatom.

Mopper, K., K. Sri Ramana and R. S. Sarpal, Use of natural protein fluorescence to estimate the protein content of seawater. To be submitted to Mar. Chem.

Presentation at National Meetings:

Ramana, K.S. and K. Mopper, 1994. Polysaccharide exudation in relation to algal flocculation. Eos, Trans. Am. Geophys. Un., 75: 34; Abstract #O11J-2.

Zhou, J. and K. Mopper, 1994. Polysaccharide composition of non-living background particles (NLBP) formed by bubble adsorption of filtered seawater taken during an algal bloom. Eos, Trans. Am. Geophys. Un., 75: 47; Abstract #O12C-17.

Ramana, K.S, J. Zhou and K. Mopper, 1996. Role of surface-active carbohydrates in particle aggregation and flocculation of a coastal diatom bloom in East Sound. Eos, Trans. Am. Geophys. Un. 76, 165; Abstract #OS41O-04.

Zhou, J., K. Mopper and U. Passow, 1996. Role of surface-active polysaccharides in the formation of transparent exopolymer particles (TEP) by bubble adsorption. Eos, Trans. Am. Geophys. Un. 76, 174; Abstract #OS42E-08.

Dam H. G., D. T. Drapeau, K. Mopper, J. Zhou, U. Passow and A. Waite, 1996. Effects of silica limitation on stickiness, carbohydrate and transparent exopoloymer particle concentration in a marine diatom. Eos, Trans. Am. Geophys. Un. 76, 147; Abstract #OS41D-16.

Theses:

Jian Zhou (WSU)	Nature & role of surface-active carbohydrate in particle aggregation in the sea.	Ph.D.	1996

Two other theses are in various stages of preparation.
Students: J. Weishaar (MS), and B. Hofsetz (Ph.D).

Patents: None.

ABSTRACT (N00014-92-J-4073)

P.I.: KENNETH MOPPER
Department of Chemistry
Pullman, Washington 99164-4630

NATURE AND ROLE OF MARINE EXUDATES IN PARTICLE AGGREGATION IN THE SEA (SIGMA ARI)

Summary of Accomplishments: The overall goal of the project was to determine the importance of dissolved and colloidal exudates in flocculation of algae in the sea. Thus, during the course of algal blooms, we 1) studied bubble-generated, non-living background particles formed from *surface active* algal exudates, since these particles appear to play a key role in floc formation; 2) determined the molecular size distribution and composition of exocellular saccharides; and 3) related changes in exopolysaccharide composition and concentration (dissolved, colloidal, and surface active substances) to particle concentration and size distribution, to the formation of transparent exopolymer particles (TEP), and to variations in viscosity of the medium, alpha (the sticking coefficient), and microbial activity (i.e., exo-enzymatic hydrolysis, remineralization and synthesis of microbial exudates).

Field Sampling: We collected exopolymer samples and bubble-generated particles during three SIGMA field experiments: a diatom bloom in a tank mesocosm (at UCSB, spring 1993), and flocculating coastal algal blooms in Monterey Bay (summer 1993), and in East Sound near Friday Harbor (spring 1994). In addition, we collected samples for flocculation and TEP formation studies from the Weddell Sea (Nov. 1993) and from Puget Sound at the Shannon Point Marine Center (Jan. 1994).

Technical Approach: Exopolymer samples and bubble-generated particles were obtained at distinct bloom phases for several study systems: a diatom bloom in a tank mesocosm and flocculating coastal algal blooms in Monterey Bay, East Sound (Friday Harbor, WA), and the Weddell Sea. Soluble exopolymers and colloids were fractionated by molecular weight using tangential flow ultrafiltration. In addition, we generated particles (flocs) by bubble adsorption using a foam fractionation tower. Acidic and neutral polysaccharides in these fractions were quantified by colorimetric methods. Acid hydrolysis/methylation procedures were employed for structural characterization of the polysaccharides. Hydrolysis products were analyzed by HPLC, capillary GC, and GC-MS to identify monomeric constituents and linkage points. We determined changes in TOC/DOC concentrations during the blooms by high temperature oxidative combustion, and changes in humic and protein fluorescence using three dimensional excitation-emission matrices.

Scientific Merit: This study has provided the first detailed molecular information on particle aggregation in the sea. This information is essential for understanding the molecular mechanisms that cause particles to adhere, and for modeling particle aggregation dynamics in the upper ocean. In addition, this study has provided important new information on the composition of marine dissolved and colloidal organic matter, and on the formation of non-living biogenic background particles. Finally, the study has provided essential analytical information for the SIGMA ARI.